Using a high-speed movie camera to evaluate slice dropping in clinical image interpretation with stack mode viewers.

AUTHOR(S):

Yakami, Masahiro; Yamamoto, Akira; Yanagisawa, Morio; Sekiguchi, Hiroyuki; Kubo, Takeshi; Togashi, Kaori

Using a high-speed movie camera to evaluate slice dropping in clinical image interpretation with stack-mode viewers

Objectives: To verify objectively the rate of slice omission during paging on picture archiving and communication system (PACS) viewers by recording the images shown on the computer displays of these viewers with a high-speed movie camera.

Methods: This study was approved by the institutional review board. A sequential number from 1 to 250 was superimposed on each slice of a series of clinical Digital Imaging and Communication in Medicine (DICOM) data. The slices were displayed using several DICOM viewers, including in-house developed freeware and clinical PACS viewers. The freeware viewer and one of the clinical PACS viewers included functions to prevent slice dropping. The series was displayed in stack-mode, and paged in both automatic and manual paging modes. The display was recorded with a high-speed movie camera and played back at a slow speed to check whether slices were dropped. The paging speeds were also measured.

Results: With a paging speed faster than half the refresh rate of the display, some viewers dropped up to 52.4% of the slices, while other well-designed viewers did not, if used with the correct settings.

Conclusions: Slice dropping during paging was objectively confirmed using a high-speed movie camera. To prevent slice dropping, the viewer must be specially designed for the purpose and must be used with the correct settings, or the paging speed must be slower than half of the display refresh rate.

Keywords: Image Quality Analysis, Video Recording, PACS Implementation, PACS Management, PACS System Performance

Introduction

Picture archiving and communication systems (PACS) are becoming increasingly popular. Diagnostic radiologists generally interpret tomographic images such as those from computed tomography (CT) or magnetic resonance imaging (MRI) by viewing them in stack-mode on a PACS viewer, because stack-mode is superior to tile-mode in terms of diagnostic accuracy and efficiency [1].

As modalities improve, increasingly thin slice images are readily available, and are gaining in popularity owing to the advantages offered in clinical diagnosis of subtle lesions and detailed structures [2]. Storing thin slice data in PACS, instead of discarding after temporal storage, is supposed to gain in popularity [3]. With continued improvement in PACS, it has become feasible to use thin slice images in daily tasks.

Thinner slice intervals require higher frame rates to maintain the same image viewing speed. For example, if the interval is 0.5 mm and the viewing speed is 3 cm per second for the absolute size, the frame rate is 60 frames per second (fps). At this rate, it is very difficult to detect slice omission and evaluate image quality precisely with the naked eye because adjacent slices are too similar to distinguish at such a high speed [4].

Nevertheless, over time we have realized in clinical image diagnosis that viewing images in stack-mode seems to be different with different PACS viewers; the images could be scattered or continuous. This subtle and ambiguous realization suggests that something may be occurring during paging interpretation, such as slice dropping, which may lead to misdiagnosis. This was the main motivation for the investigation described in this paper.

In the field of computer programming, frame dropping and tearing [5] are widely known problems among programmers handling high-speed drawing. There are some techniques available to prevent these problems, such as DirectX [6]. We have adopted DirectX for our in-house developed viewers [7], which are designed for research using Digital Imaging and Communication in Medicine (DICOM) data.

The aim of this study was to verify the rate of slice omission and image artifact occurrence during paging objectively by recording the images shown on the computer displays of clinical PACS viewers and our research viewers using a high-speed movie camera.

Materials and Methods

This study was approved by the institutional review board.

Image Data

A DICOM data series was created for these experiments. Numbers between 1 and 250 were superimposed sequentially on successive slices of a series of CT data for clinical diagnosis. The image resolution was 512 by 512 pixels and the depth was 16 bit monochrome (see Figure 1).

The original CT study was a follow-up study of aortic dissection, scanned with contrast enhancement in the arterial phase using a multi-detector computed tomography (MDCT) scanner (Aquilion, Toshiba Medical Systems, Tochigi, Japan). The slice thickness and interval were 1 mm. In our institute, slice thickness and interval of thin slice data are usually the same, which is 1mm or 0.5mm. The window level was 30 HU, and the window width was 200 HU. The data were completely anonymized before being used in the experiments.

Viewers

Several DICOM viewers were used to display the data, including a Centricity RA1000 version 3.2.2 (GE Healthcare Japan, Tokyo, Japan) as V1, an EV Insite version 2.10.7.103 (PSP Corporation, Tokyo, Japan) as V2, an XTREK VIEW version 1.1.0.1j (J-MAC SYSTEM Inc., Sapporo, Japan) as V3, a SYNAPSE version 3.2.1 (FUJIFILM Medical Co., Ltd., Tokyo, Japan) as V4, YAKAMI DICOM Tools [7] version 1.2.6.0 with DirectX for 32-bit Windows as V5, and the same without DirectX for 64-bit Windows as V6. V5 and V6 are in-house developed freeware viewers for research, while the other viewers were designed for clinical use.

Each viewer was studied using one or more of the configurations listed in Table 1. Only a few combinations of viewers and displays were examined owing to the restrictions on software licenses and system administration. V1, V3, and V4 used in the experiments were clinical PACS clients, while the other viewers were standalone ones. Although V2 originally came from a clinical PACS, it was not installed as such in our institute, and thus was used as a standalone viewer.

The dataset created for the experiments was transferred to the servers of V1, V3, and V4, which were being used for clinical image diagnosis. The dataset was also saved as DICOM files, and loaded onto V2, V5, and V6.

Programming

V5 and V6 adopted Microsoft .NET Framework 2.0 to support many versions of Windows operating systems including 32bit and 64bit ones. They were written in C# language with Microsoft Visual Studio 2010. Both V5 and V6 prevented slice dropping by synchronizing drawing with the transfer of the screen buffer to the display. This way of drawing is supported by using DirectX, a collection of application programming interfaces (API) for handling tasks related to multimedia produced by Microsoft Corporation [6].

V5 adopted Managed DirectX (MDX) [8], an API to DirectX programming under .NET developed by Microsoft, to use DirectX functions because MDX was feasible for .NET applications to adopt. However, this adoption impeded supporting 64bit operating systems due to the limitation of MDX.

V6 prevented slice dropping by calling a Windows API, “DwmFlush” [9], on finishing drawing every slice, instead of adopting MDX or calling DirectX functions directly. This API waits for any queued DirectX changes that were queued by the calling application to be drawn to the screen before returning. This API is one of Desktop Window Manager (DWM) functions [10], which is supported by both 32bit and 64bit versions of Windows Vista and later, and available when Windows Aero features [11] are activated. This function of preventing slice dropping can be turned on and off by selecting a menu of the viewer program at any time as long as available.

Displays

Several computer displays were used for this study, including a RadiForce MX-300W (EIZO NANAO Corporation, Ishikawa, Japan), a MultiSync LCD 1990SX (NEC Corporation, Tokyo, Japan), a RadiForce GS-220 (EIZO NANAO Corporation), an ACER GD245HQ (Acer Inc., Taipei, Taiwan), a FlexScan S1721 (EIZO NANAO Corporation), and a Radiforce RX211 (EIZO NANAO Corporation). Each display was studied using one or more of the configurations listed in Table 1. All the displays were used with the refresh rates set to be 60Hz, which is typical for liquid crystal displays.

Viewing

The DICOM data were displayed in stack-mode, and paged using each of the viewers in automatic and manual cine mode without skipping slices. All the images were shown in their original size of 512×512 pixels on each viewer to eliminate the effects of interpolation algorithms, such as the bi-cubic, bi-linear, and nearest-neighbor algorithms used to calculate zoomed images. The images were shown on both monochrome and color digital displays. The computers on which they were executed were rebooted, and programs other than the viewers were terminated before each experiment to ensure the best performance of the viewers.

Automatic paging was performed by all the viewers, because each of these was confirmed to have a non-skip automatic paging mode. The paging was performed under multiple speed options including the highest one by viewers supporting multiple speed options. Manual paging was performed on V1, V3, V5, and V6 by the first author’s moving the mouse continuously in the shape of the infinity symbol at a speed of between 10 and 20 cm per second as constantly as possible. This was not done with V2 and V4 because of the following limitations.

V2 type viewers were confirmed not to fix the mouse cursor during manual paging. Fixing the mouse cursor is essential for unlimited manual paging by constantly moving the mouse in a loop to prevent paging from terminating when the cursor reaches the end of the screen. V4 type viewers were confirmed not to have a non-skip manual-paging mode. Some viewers, including V4, skip slices if the paging speed is set to take precedence over the non-skipping behavior and if the paging speed is too fast to show all the slices. All viewers with this function, excluding V4, were set not to skip slices.

V3, V5, and V6 were confirmed to support non-drop drawing functions and were set with this function activated.

Recording

During paging, the display was recorded using a high-speed digital movie camera (EX-FH25, Casio, Tokyo, Japan) at 1000 fps. The Nyquist frequency of the recording was 500 Hz, which was far higher than the display refresh rate of 60 Hz. The recording resolution was 224×64 pixels, which is the maximum one available at this frame rate with this camera. Recording was performed five times for each combination of viewer and its settings. Each recording set was saved as a video file without compression.

Evaluation

The videos were played and paused repeatedly to evaluate each slice. A sample of the videos is shown in Figure 2. The numerical characters from 1 to 250 superimposed on the images were checked to see that they were all shown correctly in sequence.

The first image sequence from 1 to 250 of each video file was examined, and slice dropping and the average paging speed were recorded for evaluation. If multiple slices were dropped at one time, this was also recorded. Some slices, called “Image tearing” artifacts, were composed of fragments of two slices, as shown in Figure 3. These slices were also regarded as dropped slices, as the images were incomplete. The number of tearing occurrences was also recorded for the evaluation.

The videos were played at 29.97 fps, 0.02997 times of the recording speed of 1000 fps. This speed was considered to be acceptable to evaluate each numerical character with sufficient confidence, since the characters were changed a maximum of 1.8 times per second, that is, 0.02997 times of the display refresh rate of 60 Hz.

V1, V5, and V6 also have functions for displaying intrinsic indicators during slice skipping. These indicators were checked with the naked eye, because they should be noticeable to users. They were also checked in the video files as long as the indicator was visible within the recorded field.

Results

The results are summarized in Table 2 and Figure 4.

Some viewers, including those intended for clinical use, dropped up to 52.4% of the slices when the paging speed was faster than 30.0 fps, which was half the display refresh rate. 30.0 fps corresponded to 30.0 mm per second for absolute size with 1mm slice interval. The maximum paging speed observed was 124.5 fps. One slice was dropped by V1 at no. 3 in Table 2 with a paging speed of 30.3 fps. Multiple slices were sometimes dropped at one time. On the other hand, no viewer was found to drop slices when the paging speed was lower than 30.0 fps.

Tearing artifacts were observed in several viewers, even when the paging speed was lower than 30.0 fps.

No slice skipping was shown by the indicator functions, even when slice dropping was observed.

V3 did not exhibit slice dropping or tearing artifacts, and neither did V5 or V6 if the images were shown on the primary display running in non-drop mode. The maximum paging speed observed in these three viewers with the setting above was 60.0 fps.

Discussion

As a result of the improvement in modalities such as CT and MRI, thin slice images are readily available for clinical diagnostic imaging. Isovoxel or semi-isovoxel data are currently the preferred choice, because they are suitable for detailed diagnosis and three-dimensional image processing such as multiplanar reformation.

For clinical diagnosis using thin slice images, the paging speed easily exceeds 30.0 mm per second for absolute size, because diagnostic radiologists are normally presented with vast amounts of image data, more than 1000 slices per study on average [12], with these amounts typically increasing every year [13]. An examination using an eye-tracker revealed that three out of six radiologists had a tendency to scroll quickly and repeatedly through the lung when searching images for pulmonary nodules, while focusing on the sub-regions [14]. This method of viewing requires high-speed paging.

If a slice drops, lesions smaller than three times the size of the slice interval can be blurred because of the partial volume effect, as shown in Figure 5. Otherwise, small lesions can be noticed during fast paging if the lesion has sufficient contrast [4]. Multiple slices were sometimes dropped at the same time, which produced a higher risk of missing these lesions.

Although slice dropping leads to the risk of missing lesions, no explanation of slice omission during manual or automatic paging is contained in the user manuals of these viewers. Users have no chance of seeing any signs of slice omission, including through the skip indicators and, thus, are led to believe that they are viewing all the slices without omission.

Slice omission and tearing artifacts were observed on the displays even though all the slice images were drawn without errors by the viewer programs. Thus, the slice images were assumed to have been completely or partially dropped by the operating system, video cards, or displays. A clue to this problem is that these errors can be prevented by synchronizing drawing with the transfer of the screen buffer to the display, in other words, using so-called vertical synchronization. Thus, we surmise that the cause of these errors lies in the cooperation between the viewers and the video cards. The drawing functions in the operating system may also be involved because they mediate the application software and video cards.

It is natural for slices to be dropped with a paging speed higher than the refresh rate, since these slices are merely overwritten by subsequent slices in the screen buffer or video memory before being transferred to the display. However, slice omission was observed with a paging speed higher than half the refresh rate. A possible reason why slices were dropped with a paging speed higher than half the refresh rate, rather than the rate itself, is as follows. After drawing by a viewer program, the drawn image is supposed to be transferred to the screen buffer, which is typically transferred to the display periodically at the display refresh rate. Without synchronization of drawing with the refresh, the image might sometimes completely or partially fail to be transferred to the display at the first transfer after the drawing. A possible reason why slices were dropped by V5, in spite of the non-drop function, at no. 13 and 14 in Table 2, when the viewer was shown on secondary display is as follows. At no. 13 and 14, primary and secondary displays were connected to different graphic boards. The both graphic boards might not be synchronized with each other, and drawing through DirectX might be synchronized with the transfer to the display specified as the primary display instead of the secondary display. Confirmation of the above, however, is not within the scope of this study, because it requires disclosure of the internal implementation of drawing functions within the operating systems.

To prevent unwanted slice dropping when viewing thin slice images, it is necessary to choose an appropriate viewer and to use it with the correct settings. A quality control study of PACS viewers has been carried out [15], but this was limited to static specifications, such as brightness and contrast. Dynamic specifications during paging should also be verified and standardized. Verification included in a governmental approval process would be effective, since PACS viewers generally require this approval before deployment in a country [16].

However, V1 type viewers comprise a large share of the PACS market in the United States and Japan, according to reports available on the Internet [17, 18]. Our results indicate that a large proportion of PACS users rely on dropping viewers and will continue to do so until these viewers are upgraded to a version with slice dropping countermeasures in the future.

To reduce the possibility of missing lesions with these dropping viewers, the paging speed must be reduced to less than half the display refresh rate. Automatic cine mode is reliable for controlling the paging speed appropriately, while manual cine mode requires users to move a mouse slowly and carefully by hand. Viewing each slice multiple times may also be effective. If the rate at which slices are dropped during a single viewing is 50% for example, then the rates at which slices are dropped during double and triple viewings are 25% and 12.5%, respectively.

This study has several limitations. The viewers were limited to those available in Japan. Only a part of each of the slices was recorded because of the limitations of the resolution of the high-speed movie camera. Tearing artifacts were thus not recorded if they occurred outside the recorded area. It is hoped to include observer studies on clinical image diagnosis in the future to evaluate the speed of paging, the unevenness of the speed, the rate of slice dropping and tearing artifacts, and the impact on diagnostic accuracy.

Conclusions

In conclusion, slice dropping during paging with stack-mode PACS viewers was confirmed objectively using a high-speed movie camera. Tearing artifacts were also confirmed. To prevent slice dropping and tearing artifacts during viewing of slices in stack-mode, the viewer must be specially designed for the purpose and used with the correct settings. To prevent slice dropping without using such a specialized viewer, the paging speed must be less than half the refresh rate of the display.

Acknowledgements

We would like to extend our special thanks to Makoto Hara and Puyi Lu (J-MAC SYSTEM Inc.) for facilitating evaluation of XTREK; Koji Fujimoto, MD, PhD (Kyoto University Hospital) for procurement of the devices; Naru Toyoda (GE Healthcare Japan) for installation of the GE Centricity RA1000; and Giro Todo and Thai Akasaka (Osaka Red Cross Hospital) for enabling the evaluation of SYNAPSE.

This work is partly supported by the Innovative Techno-Hub for Integrated Medical Bio-imaging of the Project for Developing Innovation Systems, from the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan.

References

1. Mathie AG, Strickland NH: Interpretation of CT scans with PACS image display in stack-mode. Radiology 203(1):207-209, 1997

2. Jung JI, Kim KJ, Ahn MI, Kim HR, Park HJ, Jung S, Lim HW, Park SH: Detection of pulmonary embolism using 64-slice multidetector-row computed tomography: accuracy and reproducibility on different image reconstruction parameters. Acta Radiol 52(5):417-421, 2011

3. Meenman C, Daly B, Toland C, Nagy P: Use of a thin-section archive and enterprise 3D software for long-term storage of thin-slice CT data sets. J Digit Imaging 19(suppl 1):84-88, 2006

4. Holcombe AO: Seeing slow and seeing fast: two limits on perception. Trends Cogn Sci 13(5):216-221, 2009

5. Screen Tearing. Available at http://en.wikipedia.org/wiki/Screen_tearing. Accessed May 25, 2012

6. DirectX. Available at http://en.wikipedia.org/wiki/DirectX. Accessed May 25, 2012

7. YAKAMI DICOM tools. Available at http://www.kuhp.kyoto-u.ac.jp/~diag_rad/intro/tech/dicom_tools.html. Accessed May 25, 2012

8. Managed DirectX. Available at http://en.wikipedia.org/wiki/Managed_DirectX. Accessed May 25, 2012

9. DwmFlush function. Available at http://msdn.microsoft.com/en-us/library/windows/desktop/dd389405(v=vs.85).aspx. Accessed May 25, 2012

10. Desktop Window Manager. Available at http://msdn.microsoft.com/en-us/library/aa969540.aspx. Accessed May 25, 2012

11. Windows Aero. Available at http://en.wikipedia.org/wiki/Windows_Aero. Accessed May 25, 2012

12. Yakami M, Ishizu K, Kubo T, Okada T, Togashi K: Development and evaluation of a low-cost and high-capacity DICOM image data storage system for research. J Digit Imaging 24(2):190-195, 2011

13. Bhargavan M, Kaye AH, Forman HP, Sunshine JH: Workload of radiologists in United States in 2006-2007 and trends since 1991-1992. Radiology 252(2):458-467, 2009

14. RSNA Annual Meeting 2011, Scientific Informal (Poster) Presentations, Searching in three dimensions: how do radiologists move their eyes when viewing

chest CT. Available at
http://rsna2011.rsna.org/search/event_display.cfm?printmode=n&em_id=11009645. Accessed May 25, 2012
15. Siegel EL, Reiner BI, Cadogan M: Frequency and impact of high-resolution monitor failure in a filmless imaging department. J Digit Imaging 13(3):114-118, 2000
16. Health imaging hub, FDA requirements for PACS. Available via http://www.healthimaginghub.com/medical-imaging-radiology-education-cme/health-free-ebooks/697-fda-requirements-for-pacs.html?tmpl=component&print=1&layout=default&page=. Accessed May 25, 2012
17. HIMSS, Picture archiving and communication systems: a 2000-2008 study, White paper. Available at http://www.himss.org/foundation/docs/PACS_ResearchWhitePaperFinal.pdf. Accessed May 25, 2012
18. Hayashi K. [PACS market investigation report]. ITmedia. Available at http://techtarget.itmedia.co.jp/tt/news/1104/05/news02.html. Accessed May 25, 2012 (Japanese)

Figure and Table legends

Figure 1

Fig. 1. Slice image used in this study. Nine copies of each image, numbered 1 to 250, were superimposed on the image.

Figure 2

Fig. 2. Example of recorded frames shown in tile-mode. Twenty frames in a video file are shown in tile-mode. The 129th and 130th slices were dropped, but no skip signs were shown on the scroll bars on the left border of the frames.

Figure 3

Fig. 3. Example of a tearing artifact. A horizontal tearing artifact is observed in the center of this image. The upper and lower halves of the image show the 181st and 182nd slices, respectively.

Figure 4

Fig. 4. Summary of the results. The results shown in Table 2 are summarized in this graph.

Figure 5

Fig. 5. Example of the partial volume effect by slice dropping. All images of the lesion on the remaining slices are blurred owing to the partial volume effect. This can occur if the lesion size is smaller than three times the size of the slice interval.

Table1

Table 1. Hardware specifications and configuration settings used in the experiments.

Table2

Table 2. Results of all the experimental sets. The shaded rows/cells indicate combinations of settings/results with slice dropping or tearing artifacts, while the unshaded rows/cells indicate combinations without any of these errors.

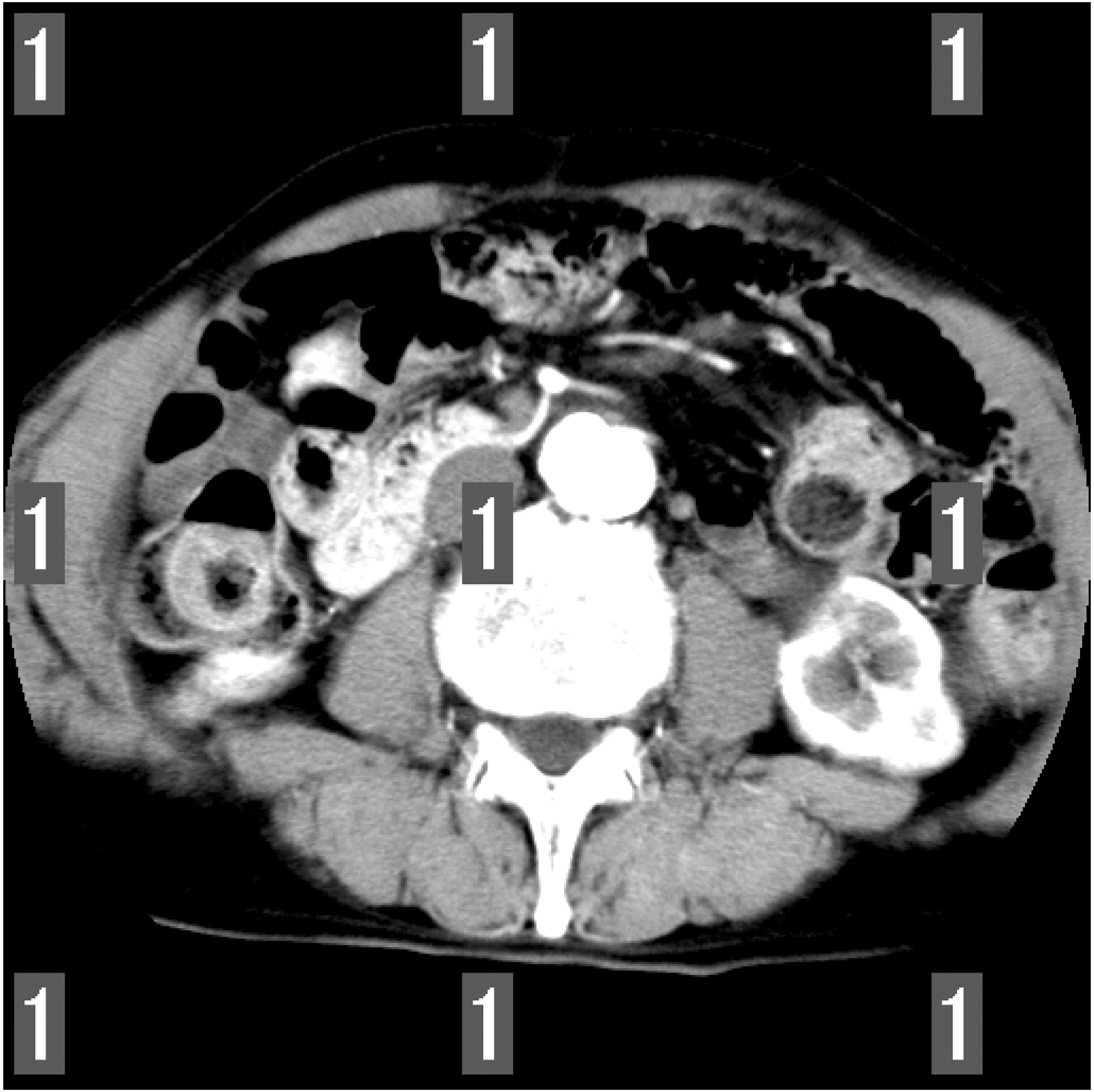


Figure 1

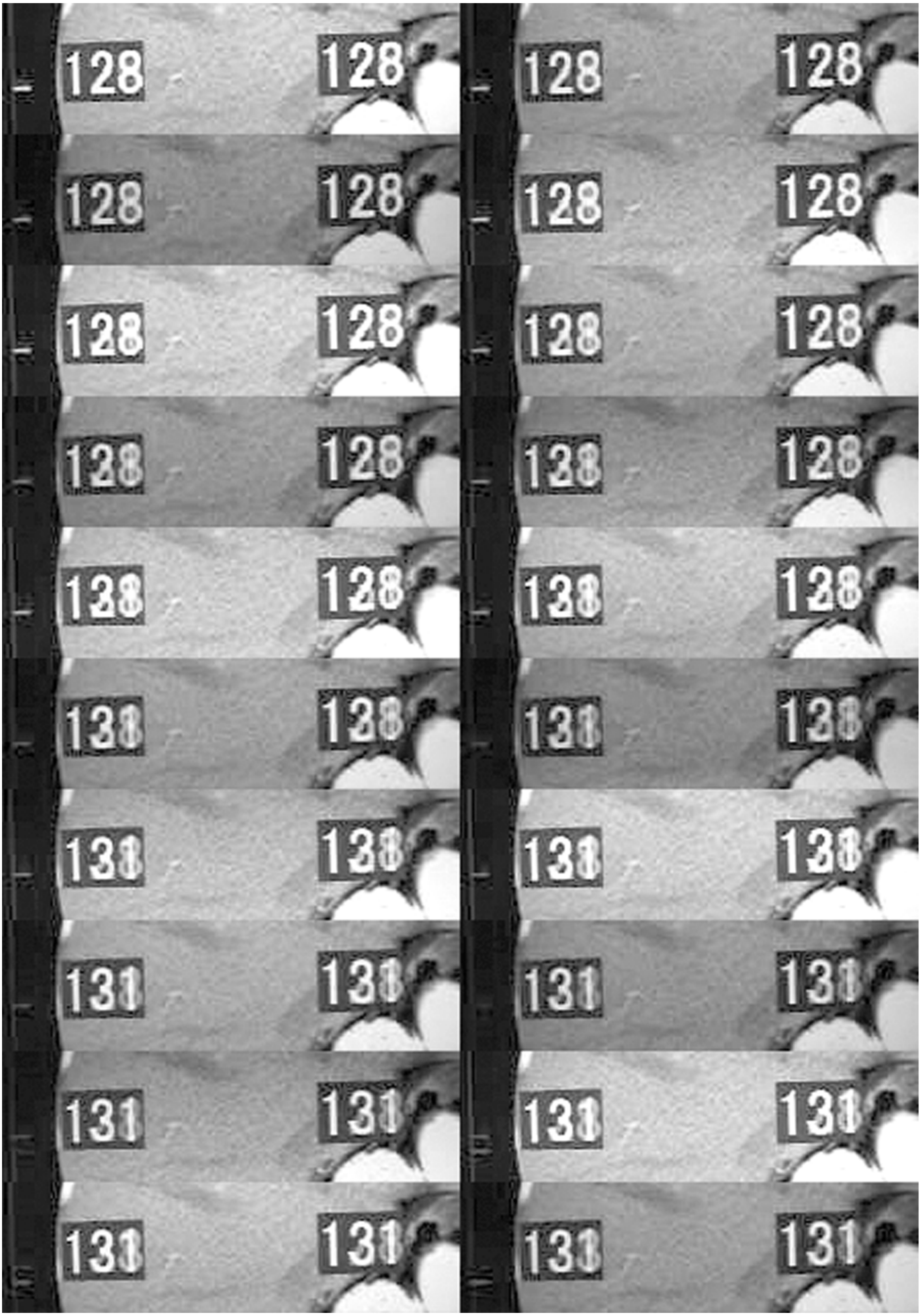
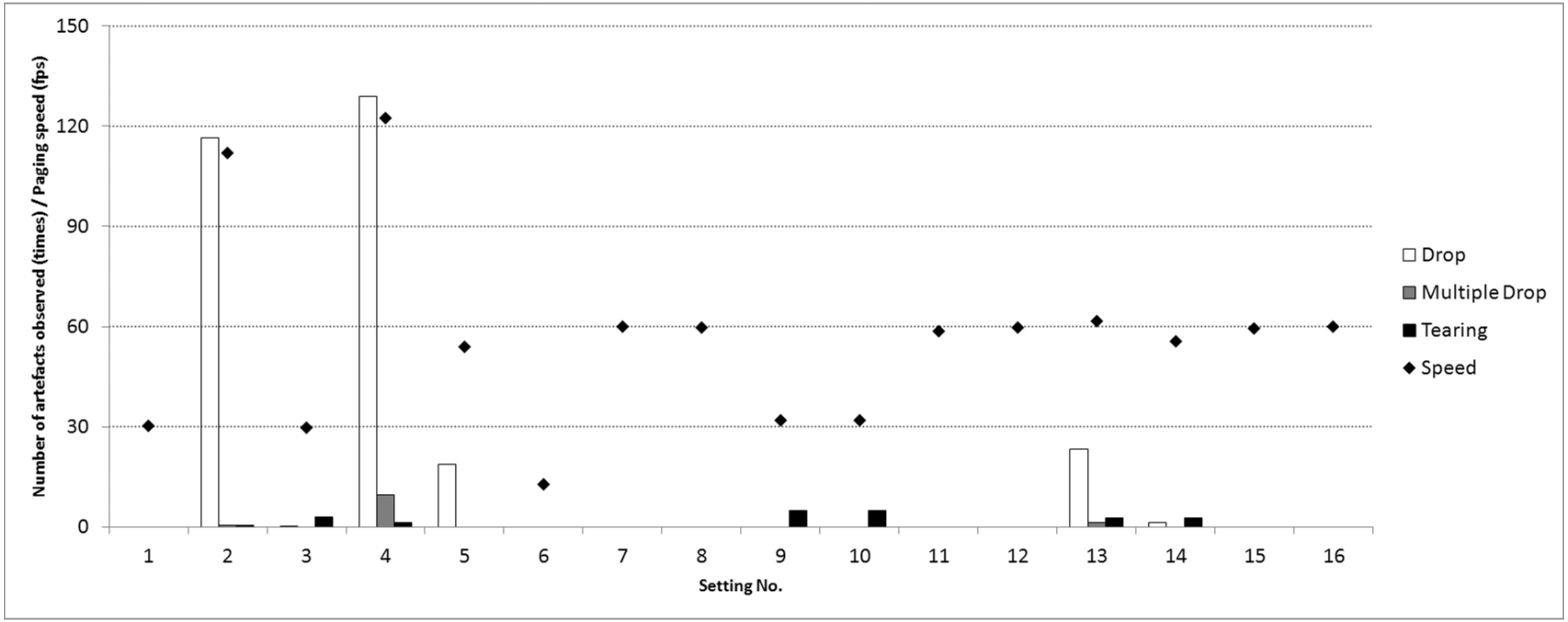


Figure 2

Figure 3



150
120
90
60
30
0
Number of artefacts observed (times) / Paging speed (fps)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Setting No.
Drop
Multiple Drop
Tearing
Speed

Figure 4

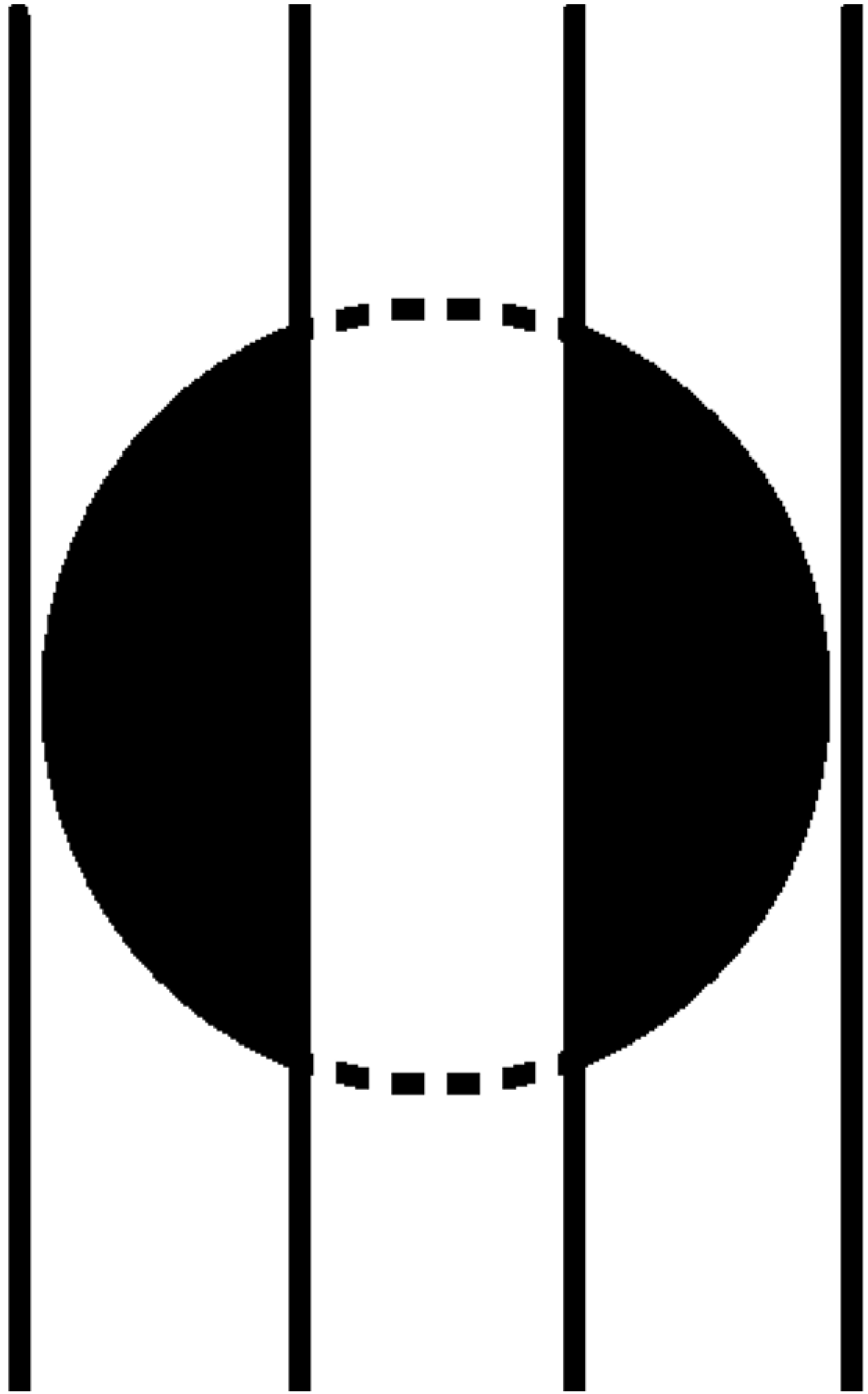


Figure 5

Table 1. Hardware specifications and configuration settings used in the experiments.

<table>
<tr><td>Configuration</td><td>1</td><td>2-1</td><td>2-2</td><td>3</td><td>4-1</td><td>4-2</td></tr>
<tr><td rowspan="2">Hardware</td><td>Z800</td><td colspan="3">Z600</td><td colspan="2" rowspan="2">OPTIPLEX 755
(Dell Japan Inc. Kanagawa Japan)</td></tr>
<tr><td colspan="4">(Hewlett-Packard Japan, Ltd., Tokyo, Japan)</td></tr>
<tr><td rowspan="4">CPU</td><td colspan="4">Xeon processors</td><td colspan="2" rowspan="2">Core™2 Duo
E6750
2.66GHz</td></tr>
<tr><td colspan="3">E5507
2.27GHz</td><td>X5650
2.67GHz</td></tr>
<tr><td colspan="3">Dual Processor</td><td colspan="3">Single Processor</td></tr>
<tr><td colspan="6">(Intel, California, USA)</td></tr>
<tr><td>Memory</td><td colspan="3">32G-byte</td><td>8G-byte</td><td colspan="2">1G -byte</td></tr>
<tr><td rowspan="2">Operating System</td><td>Windows 7
Professional
64bit,
build 7600</td><td colspan="2">Windows XP
Professional
32bit
Service Pack 2, build 2600.exsp_sp2_qfe.09084-1435</td><td>Windows 7
Ultimate
32bit
Service Pack 1</td><td colspan="2">Windows XP
Professional
32bit
Version 2002 Service Pack 2
[Version 5.1.2600]</td></tr>
<tr><td colspan="6">(Microsoft, Washington, USA)</td></tr>
<tr><td>Graphics</td><td>FirePro V5800 x2 (Advanced Micro Devices, Inc., California, USA)</td><td>FirePro V3700 (Advanced Micro Devices, Inc., California, USA)</td><td>Quadro FX 380 (NVIDIA, California, USA)</td><td>FireGL V5600 (Advanced Micro Devices, Inc., California, USA)</td><td>Q35 Express Chipset Family (Intel, California, USA)</td><td>Millennium P650 Low-profile PCI (Matrox, Quebec, Canada)</td></tr>
<tr><td>Display</td><td>RadiForce MX-300W x2 (NANAO, Ishikawa, Japan)</td><td>MultiSync LCD 1990SX x1 (NEC Corporation, Tokyo, Japan)</td><td>RadiForce GS-220 x 2 (NANAO, Ishikawa, Japan)</td><td>ACER GD245HQ x1 (Acer Inc., Taipei, Taiwan)</td><td>FlexScan S1721 x1 (NANAO, Ishikawa, Japan)</td><td>RadiForce RX211 x2 (NANAO, Ishikawa, Japan)</td></tr>
<tr><td>Resolution</td><td>2560 x 1600</td><td>1280x1024</td><td>1200x1600</td><td>1920 x 1080</td><td>1280x1024</td><td>1600x1200</td></tr>
<tr><td>Color</td><td>True color (32bit)</td><td>True color (32bit)</td><td>Grayscale (8bit)</td><td>True color (32bit)</td><td>True color (32bit)</td><td>True color (32bit)</td></tr>
<tr><td>Refresh Rate</td><td colspan="6">60Hz</td></tr>
</table>

Table 2. Results of all the experimental sets. The shaded rows/cells indicate combinations of settings/results with slice dropping or tearing artefacts, while the unshaded rows/cells indicate combinations without any of these errors.

No.	Viewer	Config. No.. of Table 1	Primary Display	Auto. Paging	Results			
					Paging Speed (FPS)	Slice dropping (in 250 slices)	Multiple dropping	Tearing
1	Centricity (V1)	1	Y	Y	30.4 SD=0.1 (30.3 -30.4)	0.0 (0.0%) (0-0)	0.0 (0.0%) (0-0)	0.0 (0.0%) (0-0)
2	Centricity (V1)	1	Y	N	111.8 SD=1.3 (109.8 -112.7)	116.4 (46.6%) SD=1.5 (114-118)	0.4 (0.2%) SD=0.5 (0-1)	0.4 (0.2%) SD=0.5 (0-1)
3	Centricity (V1)	2-2	N	Y	29.7 SD=0.8 (28.9 -30.3)	0.2 (0.1%) SD=0.45 (0-1)	0.0 (0.0%) SD=0.0 (0-0)	3.0 (1.2%) SD=1.6 (1-5)
4	Centricity (V1)	2-2	N	N	122.2 SD=1.5 (120.9-124.5)	129.0 (51.6%) SD=1.6 (127-131)	9.6 (3.8%) SD=1.1 (8-11)	1.2 (0.5%) SD=0.8 (0-2)
5	EV Insite (V2)	1	Y	Y	53.8 SD=0.7 (53.1 -54.9)	18.6 (7.4%) SD=2.3 (16-22)	0.0 (0.0%) SD=0.0 (0-0)	0.0 (0.0%) SD=0.0 (0-0)
6	EV Insite (V2)	1	Y	Y	12.8 SD=0.0 (12.8 -12.8)	0.0 (0.0%) SD=0.0 (0-0)	0.0 (0.0%) SD=0.0 (0-0)	0.0 (0.0%) SD=0.0 (0-0)
7	XTREK (V3)	3	Y	Y	60.0 SD=0.0 (60.0 -60.0)	0.0 (0.0%) SD=0.0 (0-0)	0.0 (0.0%) SD=0.0 (0-0)	0.0 (0.0%) SD=0.0 (0-0)
8	XTREK (V3)	3	Y	N	59.8 SD=0.4 (59.2 -60.0)	0.0 (0.0%) SD=0.0 (0-0)	0.0 (0.0%) SD=0.0 (0-0)	0.0 (0.0%) SD=0.0 (0-0)
9	Synapse (V4)	4-1	N	Y	32.1 SD=0.1 (32.0 -32.1)	0.0 (0.0%) SD=0.0 (0-0)	0.0 (0.0%) SD=0.0 (0-0)	4.8 (1.9%) SD=3.0 (2-9)
10	Synapse (V4)	4-2	N	Y	32.1 SD=0.1 (32.0 -32.2)	0.0 (0.0%) SD=0.0 (0-0)	0.0 (0.0%) SD=0.0 (0-0)	5.0 (2.0%) SD=4.8 (0-11)
11	YAKAMI for x86 with DirectX (V5)	2-1	Y	Y	58.7 SD=0.0 (58.7 -58.7)	0.0 (0.0%) SD=0.0 (0-0)	0.0 (0.0%) SD=0.0 (0-0)	0.0 (0.0%) SD=0.0 (0-0)
12	YAKAMI for x86 with DirectX (V5)	2-1	Y	N	59.8 SD=0.2 (59.6 -60.0)	0.0 (0.0%) SD=0.0 (0-0)	0.0 (0.0%) SD=0.0 (0-0)	0.0 (0.0%) SD=0.0 (0-0)
13	YAKAMI for x86 with DirectX (V5)	2-2	N	Y	61.8 SD=5.8 (54.9 -69.5)	23.4 (9.4%) SD=12.8 (9-39)	1.2 (0.5%) SD=1.3 (0-3)	2.6 (1.0%) SD=1.5 (1-5)
14	YAKAMI for x86 with DirectX (V5)	2-2	N	N	55.5 SD=2.8 (51.2 -57.9)	1.4 (0.6%) SD=1.9 (0-4)	0.0 (0.0%) SD=0.0 (0-0)	2.6 (1.0%) SD=1.5 (1-5)
15	YAKAMI for x64 without DirectX (V6)	1	Y	Y	59.4 SD=0.2 (59.2 -59.6)	0.0 (0.0%) SD=0.0 (0-0)	0.0 (0.0%) SD=0.0 (0-0)	0.0 (0.0%) SD=0.0 (0-0)
16	YAKAMI for x64 without	1	Y	N	60.0 SD=0.0	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)

	DirectX (V6)				(60.0 -60.0)	SD=0.0 (0-0)	SD=0.0 (0-0)	SD=0.0 (0-0)